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(71) Applicant: **ZEP SOLAR, INC.** [US/US]; 161 Mitchel Blvd., Suite 104, San Rafael, CA 94903 (US).

(72) Inventors; and
(71) Applicants : **WEST, John, Raymond** [US/US]; 161 Mitchell Blvd., Suite 104, San Rafael, CA 94903 (US). **HUDSON, Tyrus, Hawkes** [US/US]; 161 Mitchell Blvd., Suite 104, San Rafael, CA 94903 (US). **MOLINA, David** [US/US]; 161 Mitchell Blvd., Suite 104, San Rafael, CA 94903 (US). **ATCHLEY, Brian** [US/US]; 161 Mitchell Blvd., Suite 104, San Rafael, CA 94903 (US).

(74) Agent: **JOHNSON, Larry, D.**; 165 N. Redwood Dr., Suite 110, San Rafael, CA 94903 (US).

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(54) **Title**: TORQUE TUBE MOUNTED PHOTOVOLTAIC APPARATUS, SYSTEM, AND METHOD

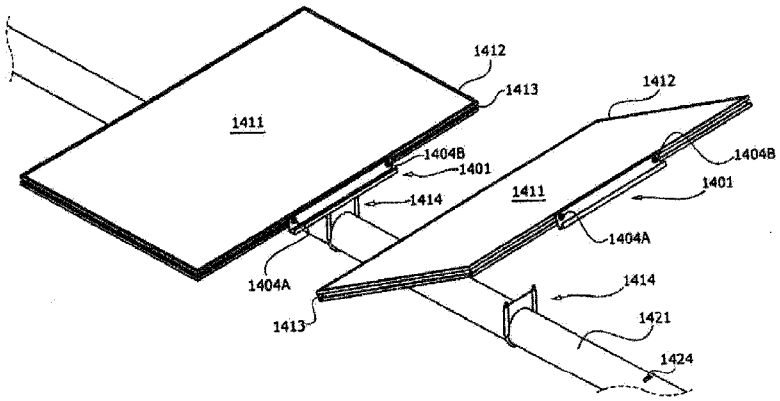


FIG. 14

(57) **Abstract**: An interlocking system for connecting photovoltaic module frames to a torque tube, including: (a) an interlock dimensioned to be positioned between the sides of two adjacent photovoltaic module frames; (b) a pair of couplings or flanges, wherein the couplings or flanges connect the interlock to both of the adjacent photovoltaic module frames; and (c) a U-lock connected to the interlock, wherein the U-lock is dimensioned to be connected to a torque tube.

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Patent Application of

John Raymond West, Tyrus Hawkes Hudson, David Molina, and Brian Atchley

for

Torque Tube Mounted Photovoltaic Apparatus, System, and Method

Technical Field:

The present invention relates to mounting systems for photovoltaic (PV) modules.

Related Application:

The present invention claims priority to US Provisional Patent Application S.N. 61/769,745, of same title, filed February 26, 2013.

Background Of The Invention:

Various embodiments and variants of an attachment device for photovoltaic (PV) module connection to other PV modules and/or associated devices has been disclosed and shown in US Provisional Patent Applications: 61/656,230 entitled: Flashing Apparatus, System and Method ", filed 6/6/2012; 61/656,240 entitled "Rail Mounted PV Apparatus, Method and System", filed 6/6/2012; and 61/698,292 entitled "Module Attachment System & Module Support System" filed 9/7/2012; as well as US Patent Application: 13/402,846 entitled: "Pivot-Fit Frame, System and Method for Photovoltaic Modules", filed 2/22/2012; each of which is incorporated by reference herein in its entirety. Other ancillary embodiments, including otherwise related or associated apparatus(es), system(s) and method(s) regarding embodiments of an interlock and other components have similarly been disclosed by applications of at least one of the named inventors hereto.

The above systems all provide effective PV attachment and mounting systems for mounting PV modules to levelling feet or rails positioned on building roofs.

However, what is now desired is a system that quickly and easily permits PV modules to be mounted onto torque tubes (which are tubes that rotate PV modules to track the motion of the sun, and thereby increase the electrical efficiency of the PV modules mounted thereon). As will be shown, the present system provides a fast, easy and convenient method of connecting a series of PV modules together on a rotatable torque tube.

Terms:

While various terms may have their ordinary meaning or particular meaning in the art, for ease of understanding there is provided herein, both below and at other locations in this specification, a non-limiting explanation as to the minimum scope intended for understanding of the present specification. Terms may be in singular or plural or any tense while retaining the same general meaning.

The term "**arm**" generally refers to a relatively narrow device, item, feature or portion of an item that extends, branches or juts-out from a mass or other part; also a slender part of a structure, machine, instrument or apparatus that projects from a main part, axis, pivot or fulcrum.

The term "**bracket**" generally refers to a simple structure with an elongate structure, sometimes in the general shape of an L or an I or a C, and frequently comprising a plate or sheet-type construction with one dimension typically thinner than the others in a given plate-like portion of the object. A bracket is often an overhanging member that projects from a structure (such as a portion of a wall or frame) and may be designed to support a load with a vertical component, such as a skirt or the like. A bracket may also refer to a fixture projecting from a wall, column, frame or the like which may be used for holding, securing, positioning or supporting another object. A bracket may also include an arm.

The term "**connector**" or "**coupling**" refers to an object, item, mechanism, apparatus, combination, feature, link or the like that links, joins, unites or fastens two or more things together.

The term "**couple**" refers to joining, linking, connecting or mating two or more objects or items, mechanisms, objects, things, structures or the like together and the term "**coupling**" refers to an object, item, mechanism, apparatus, combination, feature, link or the like that couples, joins, links, mates or connects two things together.

The term "**engage**" refers to contacting, interlocking or meshing one or more items, mechanisms, objects, things, structures or the like and "disengage" refers to detaching, freeing, loosening, extricating, separating or releasing from something that holds-fast, connects, couples or entangles.

The term "**PV array**" refers to a plurality of photovoltaic modules connected together often in a pattern of rows and columns with module sides placed close to or touching other modules. An example PV array is shown at array **1737** in **FIG. 17**, and its descriptions.

The term "**PV module**" refers to a photovoltaic module (sometimes referred to as a solar panel or photovoltaic panel), which is a packaged interconnected assembly of solar cells, also known as photovoltaic cells. A plurality of PV modules are commonly used to form a larger photovoltaic system referred to as a PV array, to provide electricity for commercial, industrial and residential applications. An example PV module is shown at module **1411** in **FIG. 14**, and its descriptions.

Summary Of The Invention:

An interlocking system for connecting photovoltaic module frames to a torque tube, including: (a) an interlock dimensioned to be positioned between the sides of two adjacent photovoltaic module frames; (b) a pair of couplings or flanges, wherein the couplings or flanges connect the interlock to both of the adjacent photovoltaic

module frames; and (c) a U-lock connected to the interlock, wherein the U-lock is dimensioned to be connected to a torque tube.

In various embodiments, couplings or flanges (or both) may be used on the interlock to connect the interlock securely between two adjacent PV module frames which are mounted onto a torque tube to track the movement of the sun over the course of the day.

One advantage of the present system is that a single interlock can be used to support a pair of adjacent PV module frames. Specifically, the interlock may have a portion that is positioned under the side edges of two adjacent PV module frames. As such, one interlock can be used to support the side edges of two PV module frames.

Further advantages include reduced costs and labor (due to the small number of parts required). The present system is also auto-grounding between the adjacent PV modules.

In one aspect, a coupling passing through the interlock can be rotated into a locked position into the side groove in one module frame with the opposite side of the coupling then being received into the side groove of the second module frame. An advantage of this approach is that the second PV module frame can be easily rotated down into a locked position after the coupling has been rotated into a locked position in the side groove of the first PV module frame. Thus, successive PV modules can quickly and easily be added to the torque tube.

In another aspect, the interlock has a pair of support portions and a pair of flanges. The flanges are positioned within the side grooves in the adjacent PV module frames while the support portions are positioned under the side edges of the two adjacent PV module frames. In this aspect, an optional bracket clip can also be used to support one end of the interlock (with the flanges supporting an opposite end of the interlock).

An advantage of the system using either embodiment of the interlock is that the ends of the interlock need only extend to a mid-portion of the PV modules. This conserves materials as it is not necessary to mount the PV modules onto rails or any other support structure that extends the full length of the module. Rather, the present interlock only extends the distance (along the sides of the module) that is desired to advantageously reduce the cantilevered end portion of the module.

Brief Description Of The Drawings:

FIG. 1 is a perspective view of a first embodiment of the interlock.

FIG. 2 is a view similar to **FIG.** 1, but with a pair of couplings positioned through apertures on a first planar portion of the device.

FIG. 3 is an elevation view taken at one end of the device seen in **FIG.** 2.

FIG. 4 is a top plan view corresponding to **FIG.** 2.

FIG. 5 is a view similar to **FIG.** 1, but showing one side of a photovoltaic module frame prior to attachment thereto.

FIG. 6 is a perspective view similar to **FIG.** 5, but viewed from a different angle.

FIG. 7 is a view similar to **FIG.** 5, but showing the side of a photovoltaic module frame after the interlock has been inserted into position within a side groove of the frame.

FIG. 8 is a view similar to **FIG.** 7, but showing the interlock in a locked position after the couplings have been rotated into a locked position.

FIG. 9 is a perspective view of a U-lock.

FIG. 10 is a perspective view of a first (i.e.: top) portion of the U-lock.

FIG. 11 is a perspective view of a second (i.e.: bottom) portion of the U-lock.

FIG. 12 is a perspective view of the device of **FIG**. 8, prior to the U-lock being attached to a torque tube.

FIG. 13 is a perspective view of the device of **FIG**. 8, after attachment to the torque tube with the U-lock.

FIG. 14 is a perspective view of a first step of sequential panels being connected together on the torque tube.

FIG. 15 is a perspective view of a second step of sequential panels being connected together on the torque tube.

FIG. 16 is a perspective view of a third step of sequential panels being connected together on the torque tube.

FIG. 17 shows three sequential panels connection together onto a torque tube.

FIG. 18 is a perspective view of a second embodiment of the interlock.

FIG. 19 is an elevation view taken at one end of the interlock seen in **FIG**. 18.

FIG. 20 is a top plan view corresponding to **FIG**. 18.

FIG. 21 is a view similar to **FIG**. 18, but showing the side of a photovoltaic module frame prior to attachment thereto.

FIG. 22 is a perspective view of a first embodiment of a bracket clip for use with the second embodiment of the interlock as shown in **FIGS**. 18 to 23.

FIG. 23 is a perspective view of the second embodiment of the interlocking system after the interlock has been attached into a side groove of a photovoltaic module frame (showing a U-lock for attachment to a torque tube).

FIG. 24 is a perspective view of a second embodiment of a bracket clip for use with the second embodiment of the device shown in **FIGS**. 18 to 23.

FIG. 25A is a side elevation view of the system in use, using the interlock of **FIG.** 1.

FIG. 25B is a view taken along line 25B-25B in FIG. 25A.

FIG. 26A is a side elevation view of the system in use, using the interlock of **FIG.** 18.

FIG. 26B is a view taken along line 26B-26B in FIG. 26A.

Detailed Description Of The Drawings:

Referring now to the figures, where like numerals generally refer to like parts, a first embodiment of the interlocking system is shown in **FIGS. 1 – 13.** A method of interlocking a plurality of PV module frames is shown in **FIGS. 14 – 17**, and a second embodiment of the interlocking system is shown in **Figs 18 -24**.

Referring first to **FIG. 1**, an interlock is shown, such as interlock **101**. **FIGS. 1 – 17** show various embodiments and/or views of an interlock, such as interlock **101**, both independently and in combination with other devices as further disclosed below. Interlock **101** may include a large, elongated first portion such as large vertical panel **102** with two or more apertures such as apertures **103a** and **103b** passing therethrough. In optional preferred aspects, apertures **103a** and **103b** are "Zep" apertures (having a proprietary shape as designed by Zep Solar of San Rafael, California), as more fully described below. First portion **102** preferably also has two or more spacers such as spacer **109a** and **109b** extending therefrom. (In preferred aspects, spacer **109a** is positioned at a top edge of first portion **102** and spacer **109b** is positioned at a mid-section of first portion **102**). A second portion **106** extends from first portion **102** extend from opposite top sides of the channel, as shown. As will be explained, second portion **106** will be positioned under a side edge of a photovoltaic module frame. The second portion **106** may or may not be load bearing, or it may be load bearing only at certain times. The present system encompasses both embodiments, which in turn depend upon both design tolerances and wind loading.

A third portion such as horizontal panel **125** extends from first portion **102**. As can be seen, third portion **125** and second portion **106** preferably extends from opposite sides of first portion **102.** Preferably, first portion **102** and fourth portion **105** are parallel to one another, and second portion **106** and third portion **125** are also parallel to one another. It is to be understood, however, that the present invention is not so limited, and that the attached claims also encompass alternate non-parallel embodiments. Similarly, first portion **102** and fourth portion **105** are preferably perpendicular to second portion **106** and third portion **125.** It is to be understood, however, that the present invention is not so limited, and that the attached claims also encompass alternate non-perpendicular embodiments. In addition, fourth portion **105** may or may not be load bearing, or it may be load bearing only at certain times.

Second portion **106** extends from first portion **102**. As can be seen, second portion **106** and spacers **109a** and **109b** extend in a first direction from first portion **102**, whereas third portion **125** extends in a second (i.e.: opposite) direction from first portion **102.**

In addition, fourth portion **105** extends from third portion **125.** As illustrated, first portion **102** extends upwardly from one side of third portion **125** and fourth portion **105** extends upwardly from an opposite side of third portion **125.**

In preferred aspects, the second and third portions are positioned at different heights with second portion **106** being an upper horizontal panel and third portion **125** being a lower horizontal panel.

Third portion **125** preferably has one or more apertures such as aperture **108a** and **108b**. Interlock **101** may be made of aluminum, another metal or alloy, plastic, composite, or other material(s) as known in the art.

Referring now to **FIG. 2**, an interlock such as interlock **201** may include one or more (two shown) couplings **204A** and **204B**. Preferably, couplings **204A** and **204B** are

"Zep" couplings. These couplings **204A** and **204B** may be installed, as by inserting or other manner, in apertures **103a** and **103b** as shown in **FIGS 1-3**.

One preferred embodiment of couplings **204A** and **204B** may include, without limitation, any of the couplings shown and/or described in the following published US patent applications: Application 2012-0298188, Application 2010-0065108, Application 2012-0125410, and Application 2011-0000526, incorporated by reference herein, as well as others having at least one common inventor to the instant disclosure. Such a "Zep" style coupling may, without limitation, be inserted into a groove, slot, hole or other female structure (herinafter "groove") as shown and described in published US Patent Application 2011-0000526, as well as others having at least one common inventor to the instant disclosure and as discussed below. Preferably, coupling **204a** or **204b** may include a key portion such as key portion **210A** or **210B** that may secure an interlock to a groove, as further discussed and described below, and as seen in Zep-style couplings.

FIGS 3 and **4** are respective end and top view of the system of **FIG. 2**.

Referring next to **FIG. 5**, an interlock such as interlock **501** may connect to both a PV module such as PV Module **511** and a U-Lock **914** (seen in **FIG. 9**), such as described below, in order to connect the PV module **511** to form a PV array which may be installed on one or more torque tubes **1321** (as seen in **FIG 13**), as described more fully below. As shown in **FIGS. 5 – 8** and others, an interlock such as interlock **501** may be partially inserted into and may lock (or otherwise securely be positioned) into a groove or channel such as groove **513** located on the perimeter of a PV module frame such as module **511**. Interlock **501** may, without limitation, (i) act as a connector between two PV modules, or between a PV module and one or more ancillary devices or structures, (ii) act as a coupling between two PV modules, or between a PV module and one or more ancillary devices or structures, or (iii) engage with a groove.

Referring now to **FIG. 6**, interlock **601** may, by way of illustration and not limitation, connect to the groove **613** of the PV module **611** as follows, and as illustrated in **FIGS. 5 – 8**. First, interlock **601** is aligned such that couplings **604A** and **604B** are level with groove **613**, with the key portions **610A** and **610B** of the couplings extending toward the groove **613**. The key portions **610A** and **610B** of the couplings **604A** and **604B** then enter groove **613** until the spacers **609a** and **609b** contact the surface of the frame **612**. Lastly, each coupling is turned clockwise to secure the interlock to the groove, as shown in **FIGS. 7 – 8**.

Referring now to **FIG. 7**, couplings **704A** and **704B** appear in the unlocked position. Referring now to **FIG. 8**, couplings **804A** and **804B** appear in the locked position, having turned to the right in the direction as indicated in the figure.

Referring to **FIGS. 9-11**, a U-Lock is shown, such as U-Lock **914**, detailed below. U-lock **914** includes a first (i.e.: upper) potion **915**, and a second (i.e.: lower) portion **916**. The ends **918** of lower portion **916** are received through cylinders **917**, projecting up through shoulders **920** of upper portion **915**. A positioning tab **919** may also be included. U-portion **916** has two ends **918A** and **918B** that are threaded, in this embodiment, to receive a nut. U-Lock **914** may be made of aluminum, another metal or alloy, or other material as known in the art. Ends such as ends **918A** and **918B** may use connection methods other than threading for a bolt, such as friction, an adhesive, a spring clip or other methods as known in the art.

It is to be understood that the present system encompasses numerous U-lock embodiments, including any mounting hardware for connection to a torque tube. Torque tubes are circular, rectangular, etc. Thus, the present U-lock may be suited to encompass a cylindrical torque tube (as illustrated) or any other torque tube having any particular cross section.

Referring now to **FIG. 12**, and by way of illustration and not limitation, interlock such as interlock **1201** may connect to a U-Lock **1214** as follows. The top portion **1215** of the U-Lock **1214** is positioned beneath interlock **1201** such that the

cylinders **1217A** and **1217B** are oriented vertically directly beneath apertures **1208B** and **1208B**, and the interlock **1201** rests on the shoulders **1220a** and **1220b** of the cylinders **1217A** and **1217B**. The ends **1218A** and **1218B** of the U-portion **1216** then enter the bottom of the cylinders **1217A** and **1217B**, pass through those cylinders **1217A** and **1217B**, and pass through the apertures **1208A** and **1208B**. A washer such as washers **1222A** and **1222B** may then placed on each end of the U-portion **1216**, and a nut such as nuts **1223A and 1223B** may be secured to each end **1218A** and **1218B**. **FIG. 12** shows a flat washer for illustrative purposes, but the washer may be split, springing, spherical, or another manner of washer, as may be known in the art. The washer may be metal, plastic, rubber, composite, or other material(s), as may be known in the art. Another PV module or an ancillary device or structure may, but need not, be connected to the opposite side of the interlock **1201** thereafter, as shown in **FIGS 14 – 17**.

Referring now to **FIG. 13**, a U-Lock such as U-Lock **1314** is shown, which is similar to U-Lock **914**. U-Lock **1314** may, without limitation, connect to interlock such as interlock **1301** as discussed above. A U-Lock such as U-Lock **1314** may further engage a torque tube such as torque tube **1321**, which may, by way of example and not limitation, be embodied as a cylinder with a diameter slightly less than that of the ring formed by the U-Lock **1314**. Such a torque tube may include, along its length, a row of slots such as slot **1324** of a size equal to or slightly larger than that of the tab **1319**. Such slots may be pre-cut, formed on site, formed by tab **1319** piercing the torque tube, or otherwise formed as known in the art. Tab **1319** of an U-Lock **1314** may be inserted into an aperture in the torque tube, with the top portion **1315** of the U-Lock **1314** half encircling the torque tube. The U-portion **1316** of the U-Lock **1314** then connects to the top portion **1315** so the U-Lock **1314** fully encircles the torque tube **1321**. The ends **1323A** and **1323B** of the U-portion **1314** then pass through the apertures **1308A** and **1308B** of the interlock **1301** to complete the connection to the torque tube **1321**. Additional PV modules connect to the interlock as described herein. A torque tube may rotate axially a designated number of degrees in either direction. The connection of the U-Lock to the torque

tube and PV modules (using an interlock or other method) rotates the PV modules with the torque tube to increase the exposure of the PV modules to sunlight.

FIGS. 14 - 16 illustrate successive method steps of sequential panels being connected together onto the torque tube. **FIG. 17** shows three sequential panels connection together onto a torque tube. In **FIG. 14**, a first PV module frame (on the left) has been connected onto torque tube **1421** using the system described herein. Specifically, couplings **1404a** and **1404b** are rotated to lock interlock **1401** onto the right side of the first PV module frame. At this time, the key portion (**310a** in **FIG. 3**) is rotated into a locked position in the side groove of the first PV module. A second PV module frame (on the right) is about to be pivoted downwardly into position. Next, in **FIG. 15**, the left edge of the second PV module frame is placed on top of the second vertical panel (e.g. **305** in **FIG. 3**) of interlock **1401**. At this time, the tongue portion (**304a** in **FIG. 3**) is ready to be received into the side groove of the second PV module. Next, in **FIG. 16**, the second PV module frame is pivoted downwardly into a locked position in alignment with the first PV module frame. At this time, the tongue portion (**304a** in **FIG. 3**) of the interlock is locked into the side groove of the second PV module (seen on the right).

As seen in **FIG. 17**, the process can be repeated such that additional PV module frames can be added. (**FIG. 17** shows three PV module frames. It is to be understood that the present system is not so limited, and that any number of PV module frames can be added). As can be seen, an interlock such as interlock **1701** along with an U-Lock such as U-Lock **1714** may connect PV modules such as PV modules **1711** to a torque tube such as torque tube **1721**, to permit the torque tube **1721** to rotate the connected PV modules **1711** to increase their exposure to the sun by following the path of the sun. Moreover, an advantage of the present system is that a single interlock can be connected to a PV module frame on either side.

FIG. 18 shows another embodiment of an interlock, such as interlock **1826**, which is similar to interlocks **101 - 1701**, as shown in **FIGS. 1 - 17** and others. Interlock **1826** may include two flanges **1827A** and **1827B** (at one end of the interlock as

best seen in FIG. 20), and two support portions **1828A** and **1828B** (extending the remainder of the length of the interlock as also best seen in **FIG. 20**). Two or more apertures **1830a** and **1830b** pass through the center portion **1929** (best seen as channel **1929** in FIG. **19** and channel **2029** in **FIG. 20**). It is to be understood, however, that the center portion of the device need not be a channel. Instead, the present claims also encompass embodiments having alternate shapes and designs, including, but not limited to panels, blocks of material, etc.

Both flanges (labelled as **1827**, **1927** and **2027**) and support portions (labelled as **1828**, **1928** and **2028**) extend outwardly from horizontal channel center portion (**1929**). Preferably as well, flanges (**1827**, **1927** and **2027**) and support portions (**1828**, **1928** and **2028**) extend outwardly from opposite top sides of elongated horizontal channel (**1929**) as best seen in **FIG. 19**. Interlock **1826, 1926, 2026** may be made of aluminum, another metal or alloy, or other material as known in the art.

Referring now to **FIG. 21**, and by way of illustration and not limitation, an interlock such as interlock **2126** may connect to the frame of a PV module such as PV module **2111** as follows. A flange such as flange **2127A** or **2127B** may enter the groove **2113**, curving over the lower lip or edge **2140** of the groove. The interlock **2126** is then rotated downward such that the support portion **2128A** or **2128B** slides beneath the lower lip **2140** of the groove **2113** while the flange **2127A** or **2127B** continues to arc over the lower lip **2140** and into the groove **2113**. The interlock **2126**, frame **2112**, or both may flex or otherwise deform while connecting. The connection is complete when the support portion **2128A** or **2128B** has slid beneath the lower lip **2140** such that the horizontal channel / center portion **2129** of the interlock is parallel to the groove **2113**.

Referring now to **FIG. 22**, a bracket clip such as bracket clip **2231** is shown. Bracket clip **2231** may include an arm **2232** with a catch **2233**, an upper tooth **2234** and a lower tooth **2235**. Bracket clip **2231** may be made of aluminum, another metal or alloy, or other material as known in the art.

Referring now to **FIG. 23**, a U-Lock is shown such as U-Lock **2314**, which is similar to U-Locks **914** and **1314**. Without limitation, U-Lock **2314** may connect to an interlock such as interlock **2326** and ultimately to a torque tube as described above. As a result, the interlock such as interlock **2326** may connect a PV module such as PV module **2311** to a U-Lock such as U-Lock **2314** and then to a torque tube as discussed above.

Bracket clip **2331** may connect to an interlock **2326** and a PV module **2311** that are connected to one another as described above. By way of illustration and not limitation, bracket clip **2331** may connect as follows. First, the upper tooth **2334** is placed in the groove **2313** and then positioned as closely as possible to the end of the lower flange **2328A** or **2328B**. The lower tooth **2235** is then rotated under the lower flange **2328A** or **2328B** until the lower tooth **2235** contacts the underside of the lower flange **2328A** or **2328B**. Next, the arm **2332** may be pressed downward such that the arm **2332** flexes or otherwise temporarily deforms until the catch **2333** is level with the groove **2312**. The catch **2333** is then moved into the groove **2312** until it clears the upper lip **2339** of the groove. Next, the arm **2332** is then released, causing it to "spring" upward, pressing the catch **2333** back up into the groove. The bracket clip **2331** thus "locks" the interlock **2326** to the frame **2312**. The installed bracket clip **2331** prevents the lower flange **2328A** or **2328B** of the interlock **2326** from moving away from the frame **2312**, so the interlock **2326** cannot disengage from the frame **2312**. Thus, the bracket clip **2331** secures and maintains the connection of the interlock **2326** to the frame **2312**. In other embodiments, the interlock may have an upper flange on each end and connect to the frame and groove of the module with or without a bracket clip. In still another embodiment, the interlock may have a series of upper flanges spaced along its length to connect to the frame and groove of the module with or without a bracket clip. By way of illustration and not limitation, an interlock such as interlock **2326** may connect to a U-Lock such as U-Lock **2314** in the same manner as interlock **1301** connects to U-Lock **1314**.

Referring lastly to **FIG. 24**, which shows an alternate embodiment of a bracket clip, such as bracket clip **2436**. Bracket clip **2436** is similar to bracket clip **2231** and **2331** discussed above and shown and described in **FIGS. 21 – 22** and others. A bracket clip such as bracket clip **2436** may include an arm **2432** with a catch **2433**, an upper tooth **2434**, a lower tooth **2438**, and a stopper **2437**. A bracket clip such as bracket clip **2436** may be made of aluminum, another metal or alloy, or other material as known in the art.

In operation, a bracket clip **2436** may connect to a PV module such as PV module **2311** that is connected to an interlock such as interlock **2326**. By way of illustration and not limitation, the bracket clip **2436** may connect to a groove such as groove **2313** by angling the upper tooth **2434** into the groove **2313** and then rotating the bracket clip **2436** downward such that the lower tooth **2438** slides beneath the lower lip **2340** of the groove **2313**. Next, the arm **2432** may be pressed downward such that the arm **2432** flexes or otherwise temporarily deforms until the catch **2433** is level with the groove **2313**. The catch **2433** is then moved into the groove **2313** until it clears the upper lip **2339**. The arm **2432** is then released, causing it to "spring" up, pressing the catch **2433** securely into the groove.

Connecting the bracket clip **2436** to the groove **2313** prevents the bracket clip **2436** from moving laterally along or disengaging from the groove **2313**. Bracket clip **2436** may therefore secure an interlock such as **2326** to a groove such as groove **2313**. Where a bracket clip **2436** is installed in a frame connected to an interlock such that the stopper **2437** of the bracket clip **2436** contacts or nearly contacts the lower flange **2328A** or **2328B** of the interlock **2326**, the bracket clip **2436** "locks" the interlock **2326** to the groove **2313**. The installed bracket clip **2436** prevents the lower flange **2328A** or **2328B** from moving away from the groove **2313**, so the interlock **2326** cannot disengage from the groove **2313**.

Lastly, **FIG.** 25A is a side elevation view of the system in use, using the interlock of **FIG.** 1; and **FIG.** 26A is a side elevation view of the system in use, using the interlock of **FIG.** 18. **FIG.** 25B and FIG. 26B are views taken along line 25B-25B and 26B-26B.

Specifically, in **FIGS**. 25A and 25B, interlock **2501** has couplings **2504** passing therethrough with the key portion **2510** locking into the side groove of one PV module and the tongue portion **2504** locking into the side groove of the second PV module. Similarly, in **FIGS**. 26A and 26B, interlock **2601** has flanges **2627** received into the side grooves of the module with support portions **2628** received under the side edges of the adjacent PV modules. As can be seen in both **FIGS**. 25 and 26, an advantage of the present system is that the interlocks do not extend along the full side length of the PV modules. Rather, the ends of the interlock are attached to the PV modules at a distance mid-way along the sides and the PV module frames to the torque tube. This provides a balance between material conservation and reduction of the cantilevered portion of the PV module frames. By providing a supporting structure for mounting PV module frames onto a rotating torque tube, as illustrated, the present system permits larger, heavier module frames to be used, including , but not limited to, 72 cell PV module frames.

What Is Claimed Is:

1. An interlocking system for connecting photovoltaic module frames to a torque tube, comprising:

(a) an interlock dimensioned to be positioned between the sides of two adjacent photovoltaic module frames, wherein the interlock has a pair of apertures passing therethrough;

(b) a pair of couplings, each coupling passing through one of the apertures in the interlock, and wherein each coupling is inserted into and connects the interlock to both of the adjacent photovoltaic module frames; and

(c) a U-lock connected to the interlock, wherein the U-lock is dimensioned to be connected to a torque tube that rotates to track the sun.

2. The interlocking system of claim 1, wherein the couplings are positioned at opposite ends of the interlock.

3. The interlocking system of claim 1, wherein a portion of the interlock is positioned under a side edge of each of the photovoltaic module frames.

4. The interlocking system of claim 1, wherein each coupling includes a key portion that rotates to secure the coupling into a locked position within a groove in the side of the first photovoltaic module frame.

5. The interlocking system of claim 4, wherein each coupling includes a tongue portion opposite the key portion, and wherein the tongue portion is received into a groove in the side of the second photovoltaic module frame.

6. The interlocking system of claim 1, wherein the opposite ends of the interlock are connected to the adjacent photovoltaic module frames at a distance mid-way along the sides of the adjacent photovoltaic module frames.

7. The interlocking system of claim 6, wherein the connection of the interlock to the photovoltaic module frames at a distance mid-way along the sides of the adjacent photovoltaic module frames minimizes the cantilevered portion of the photovoltaic module frames.

8. The interlocking system of claim 1, wherein the interlock comprises:

a first portion having at least one aperture passing therethrough;

a second portion extending from the first portion;

a third portion extending from the first portion, wherein the second and third portions extend from opposite sides of the first portion; and wherein the third portion has at least one aperture passing therethrough; and

a fourth portion extending from the third portion.

9. The interlocking system of claim 1, wherein the U-lock comprises:

a first portion passing through the at least one aperture in the third portion of the interlock, and

a second portion connected to the first portion of the U-lock.

10. An interlock for connecting adjacent photovoltaic module frames together, comprising:

a first portion having at least one aperture passing therethrough;

a second portion extending from the first portion;

a third portion extending from the first portion, wherein the second and third portions extend from opposite sides of the first portion; and wherein the third portion has at least one aperture passing therethrough; and

a fourth portion extending from the third portion.

11. The interlock of claim 10, wherein the first, second, third and fourth portions are essentially planar.

12. The interlock of claim 10, wherein the second and third portions are substantially parallel to one another, and the first and fourth portions are substantially parallel to one another.

13. The interlock of claim 10, further comprising:

a pair of spacers extending from the first portion of the interlock, wherein the pair of spacers are received in the groove of the photovoltaic module frame when the coupling is in the locked position.

14. The interlock of claim 10, wherein the first and second portions are perpendicular to one another, the first and third portions are perpendicular to one another, and the third and fourth portions are perpendicular to one another.

15. An interlocking system for connecting photovoltaic module frames to a torque tube, comprising:

(a) an interlock dimensioned to be positioned between the sides of two adjacent photovoltaic module frames, wherein each interlock comprises:

(i) a center portion;

(ii) a pair of support portions extending from opposite sides of the center portion; and

(iii) a pair of flanges extending from opposite sides of the center portion, wherein the pair of flanges are received into grooves in the sides of the adjacent photovoltaic module frames; and

(b) a U-lock connected to the interlock, wherein the U-lock is dimensioned to be connected to a torque tube.

16. The interlocking system of claim 15, wherein the center portion of the interlock is a channel, the pair of support portions extend from opposite top sides of the channel, and the pair of flanges extend from opposite top sides of the channel.

17. The interlocking system of claim 15, further comprising:

a bracket clip comprising:

an arm,

a catch disposed at a distal end of the arm,

an upper tooth disposed at a proximal end of the arm, and

a lower tooth disposed at the proximal end of the arm.

18. The interlocking system of claim 17,

wherein the upper tooth is dimensioned to be received into the groove against a lower edge of the groove,

wherein the lower tooth is dimensioned to be received under one of the support portions of the interlock, and

wherein the catch is dimensioned to be received into the groove against the upper edge of the groove.

19. The interlock of claim 17, wherein the bracket clip flexes such that the upper tooth and catch can be positioned within the groove.

20. The interlocking system of claim 15, wherein the U-lock comprises:

a first portion passing through the at least one aperture in the third portion of the interlock, and

a second portion connected to the first portion of the U-lock.

21. An interlock for connecting adjacent photovoltaic module frames together, comprising:

a center portion;

a pair of support portions extending from opposite sides of the center portion; and

a pair of flanges extending from opposite sides of the center portion,

wherein the pair of support portions are positioned under adjacent photovoltaic module frames when the pair of flanges are received into grooves in the sides of the adjacent photovoltaic module frames.

22. The interlock of claim 21, wherein the center portion is a channel, the pair of support portions extend from opposite top sides of the channel, and the pair of flanges extend from opposite top sides of the channel.

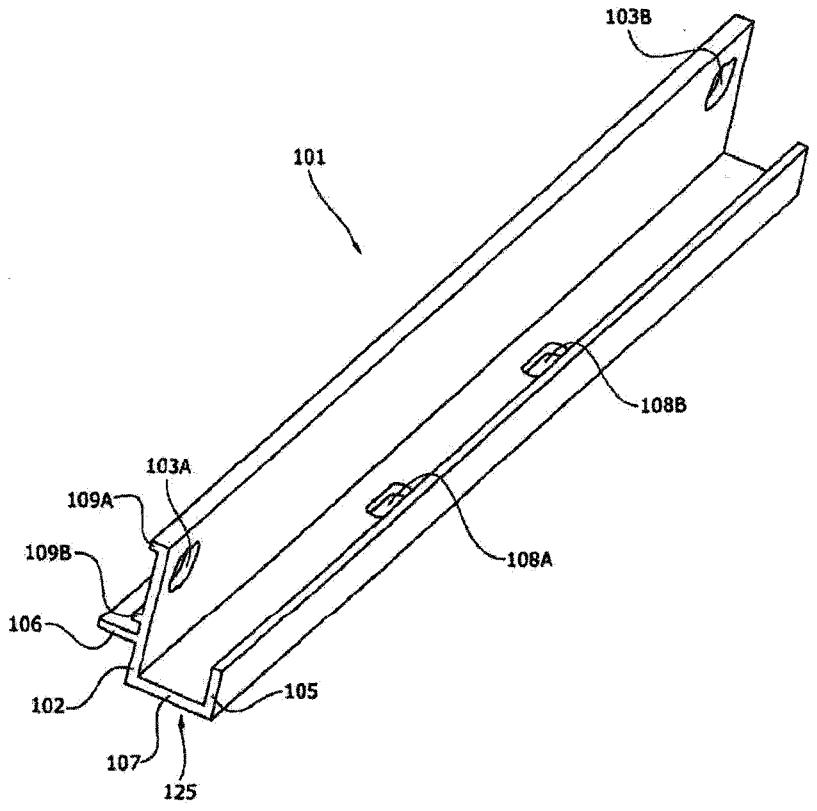


FIG. 1

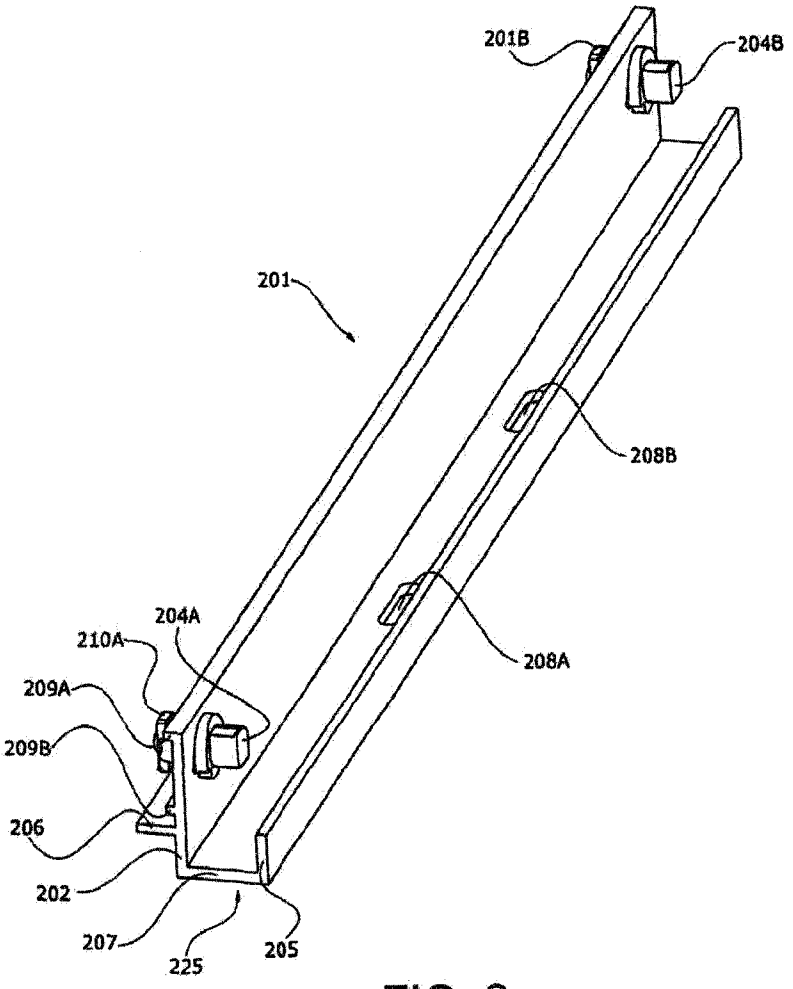

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FIG. 2

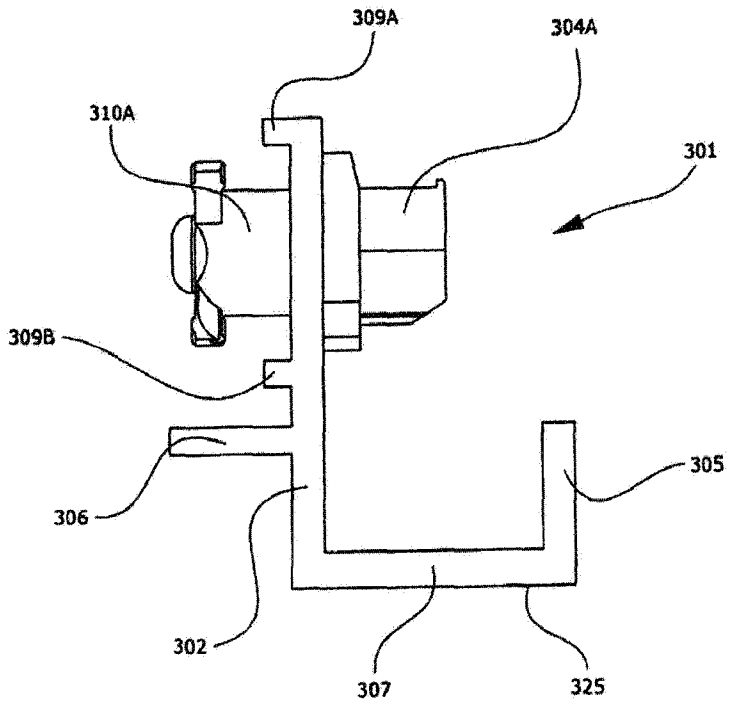


FIG. 3

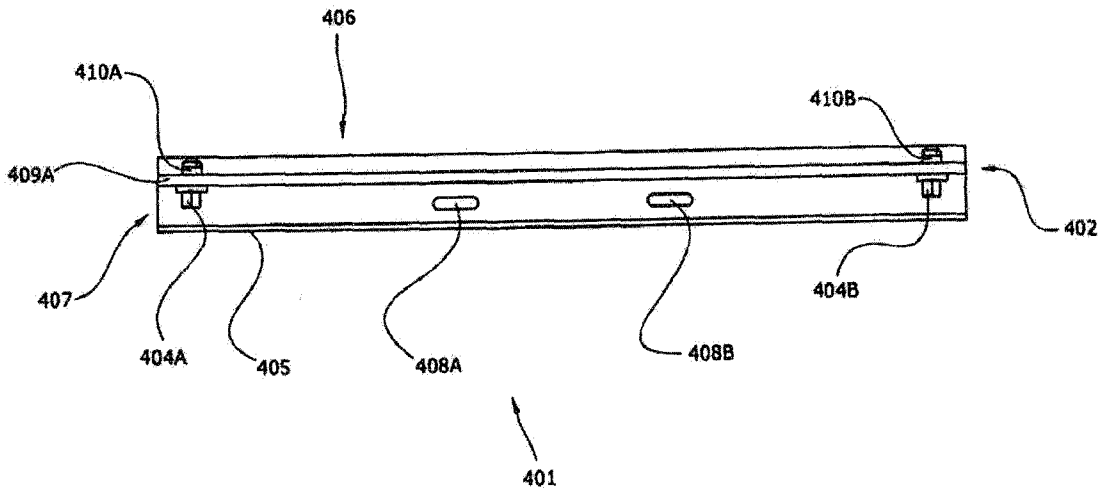


FIG. 4

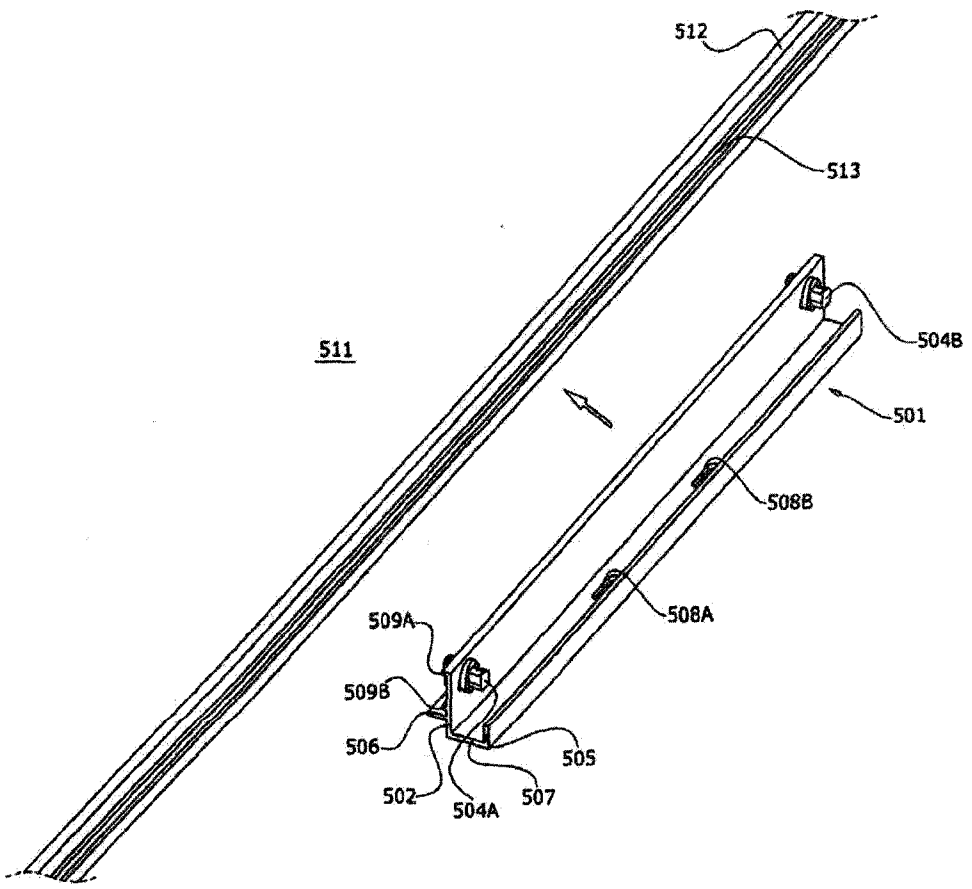


FIG. 5

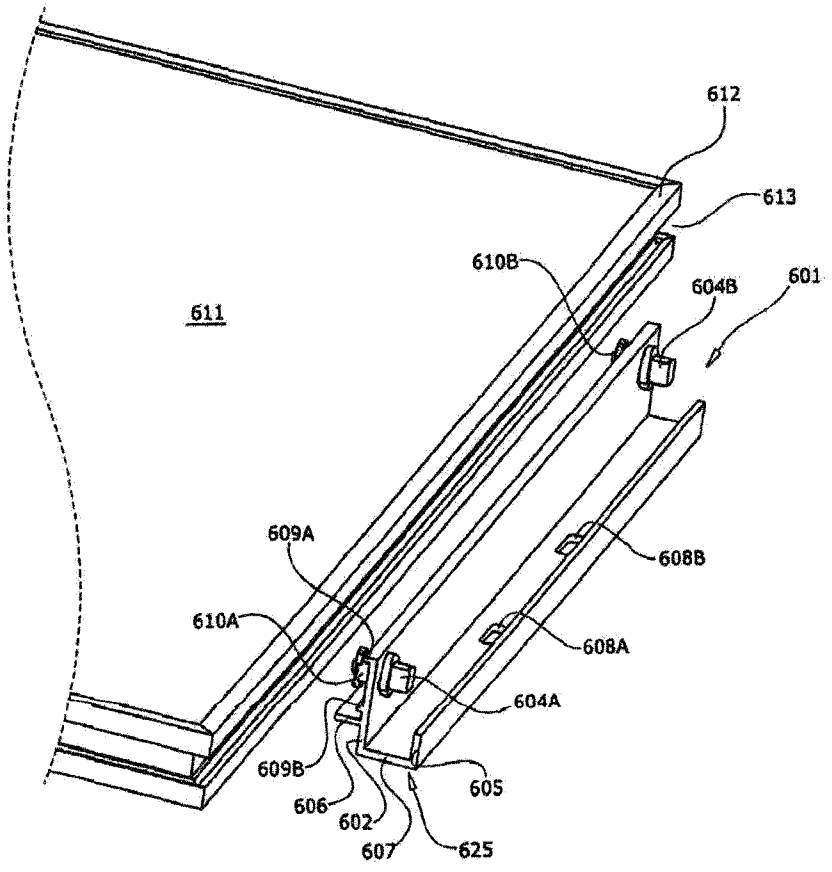

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FIG. 6

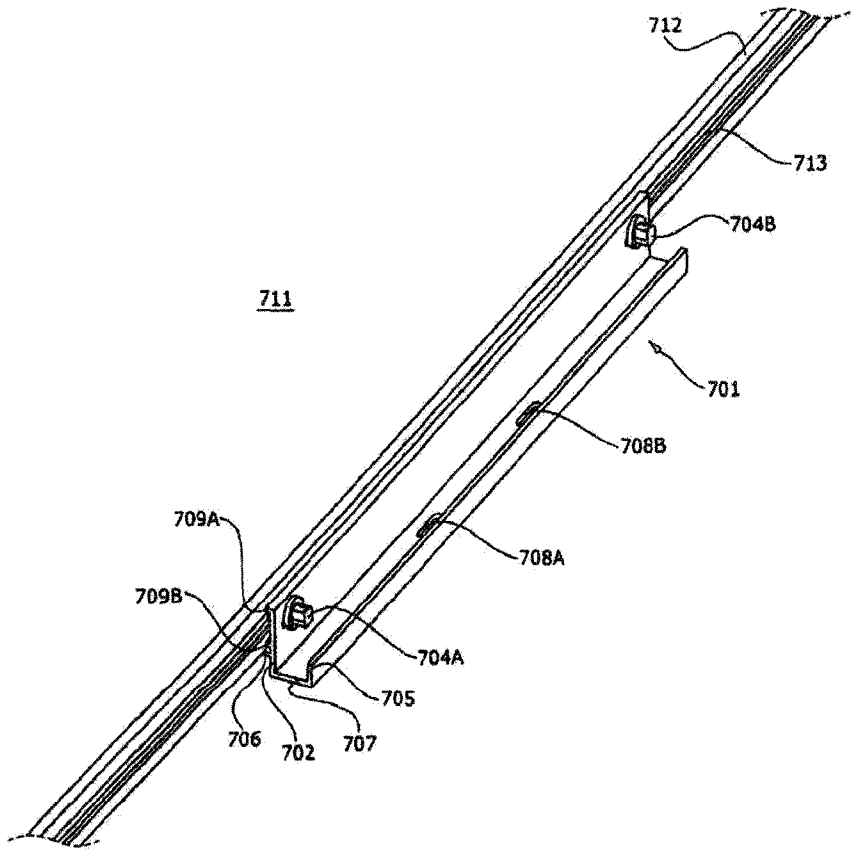


FIG. 7

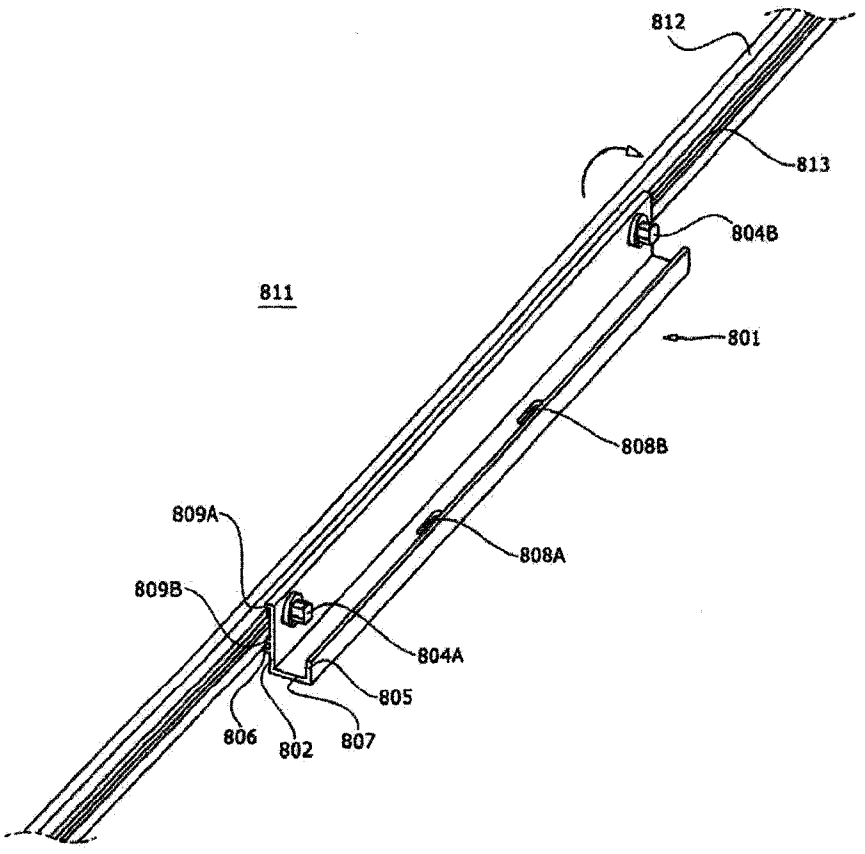


FIG. 8

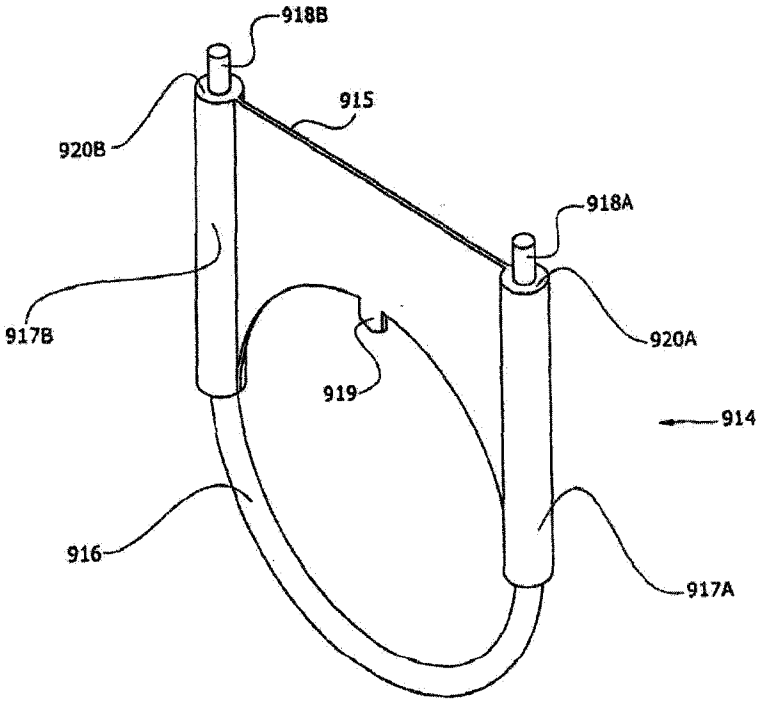


FIG. 9

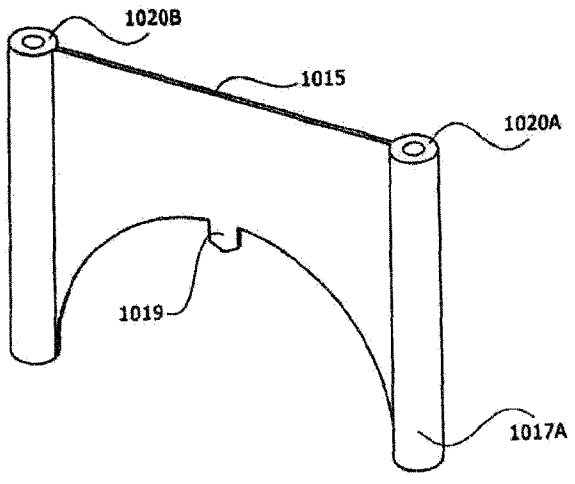


FIG. 10

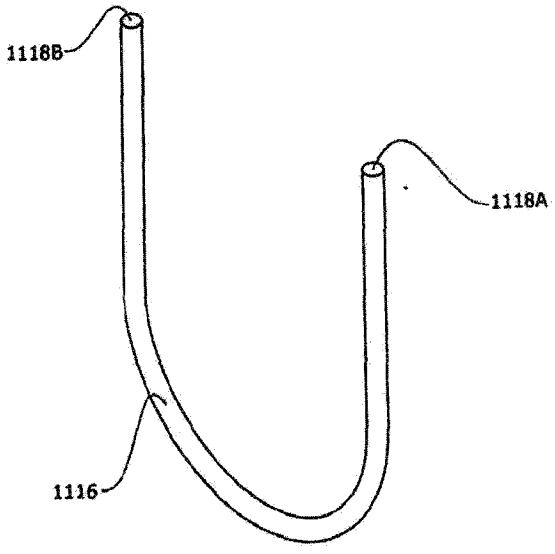


FIG. 11

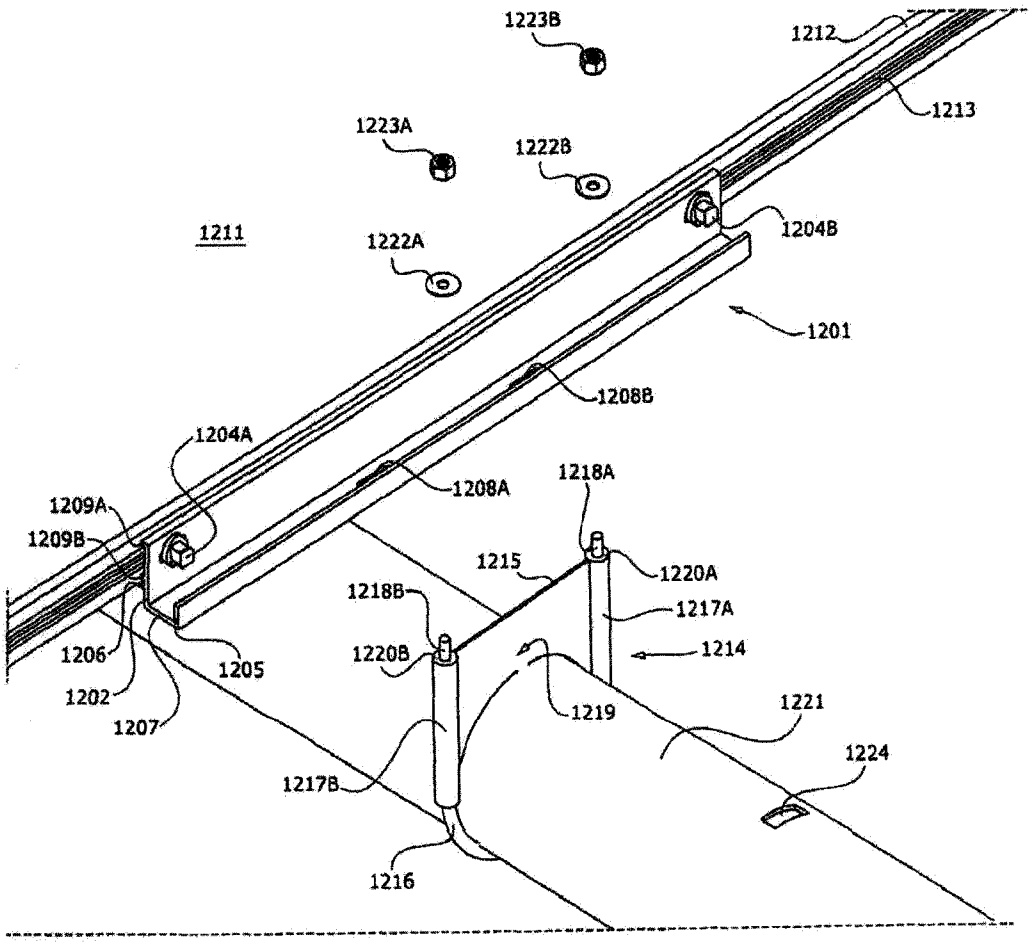

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1209B
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FIG. 12

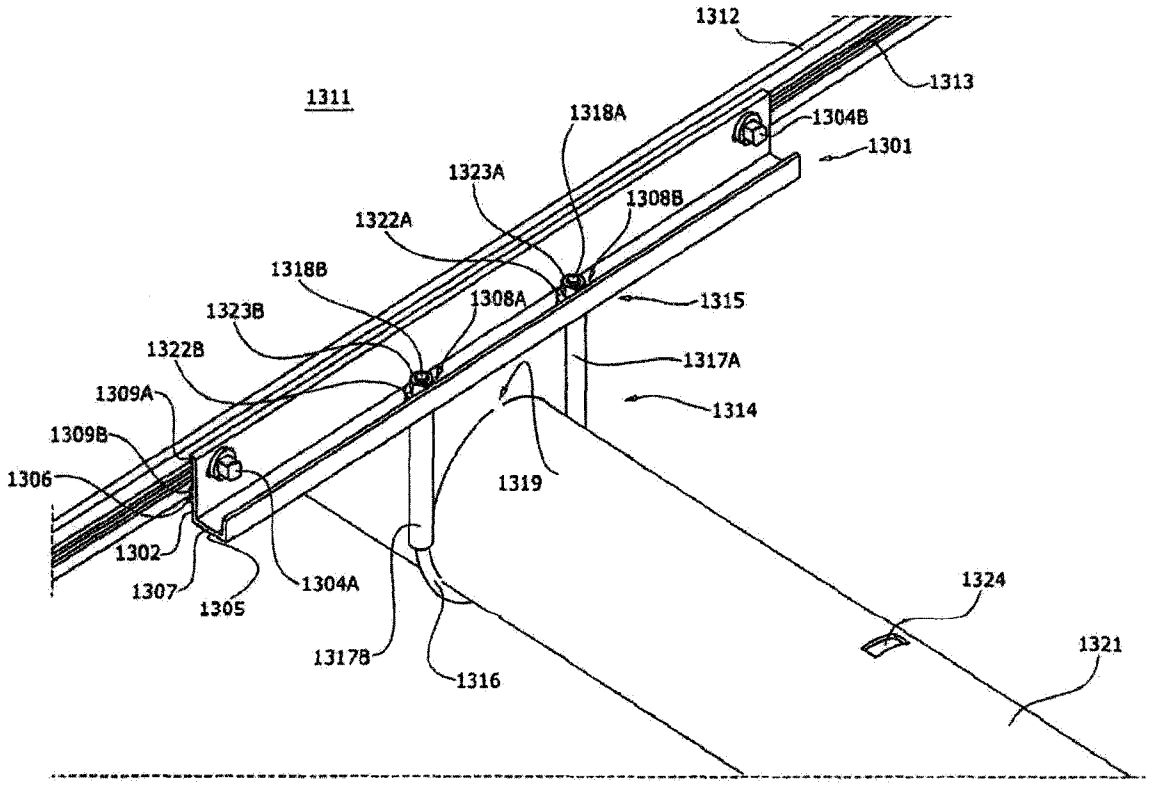

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1308B
1322A
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FIG. 13

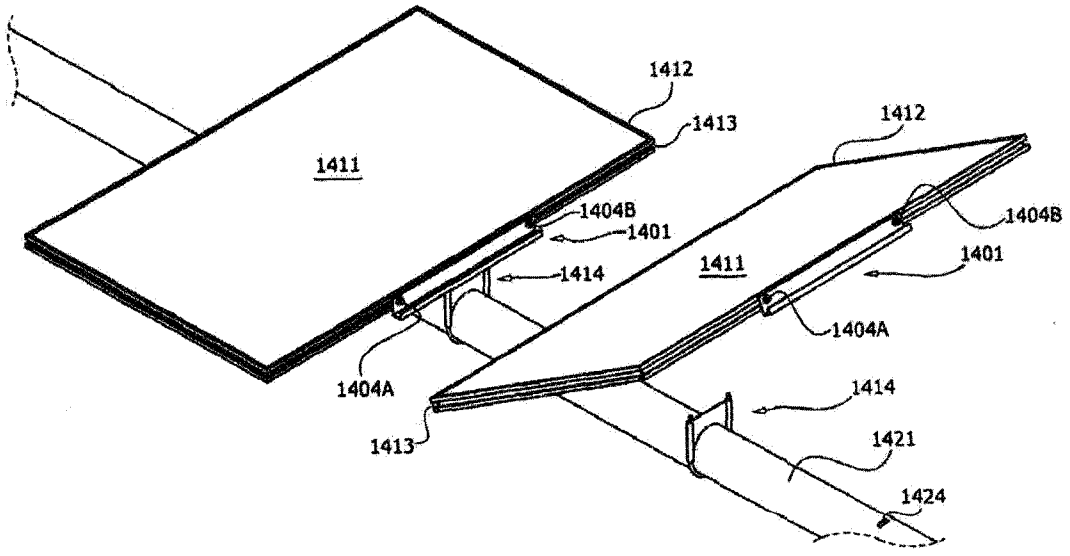

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FIG. 14

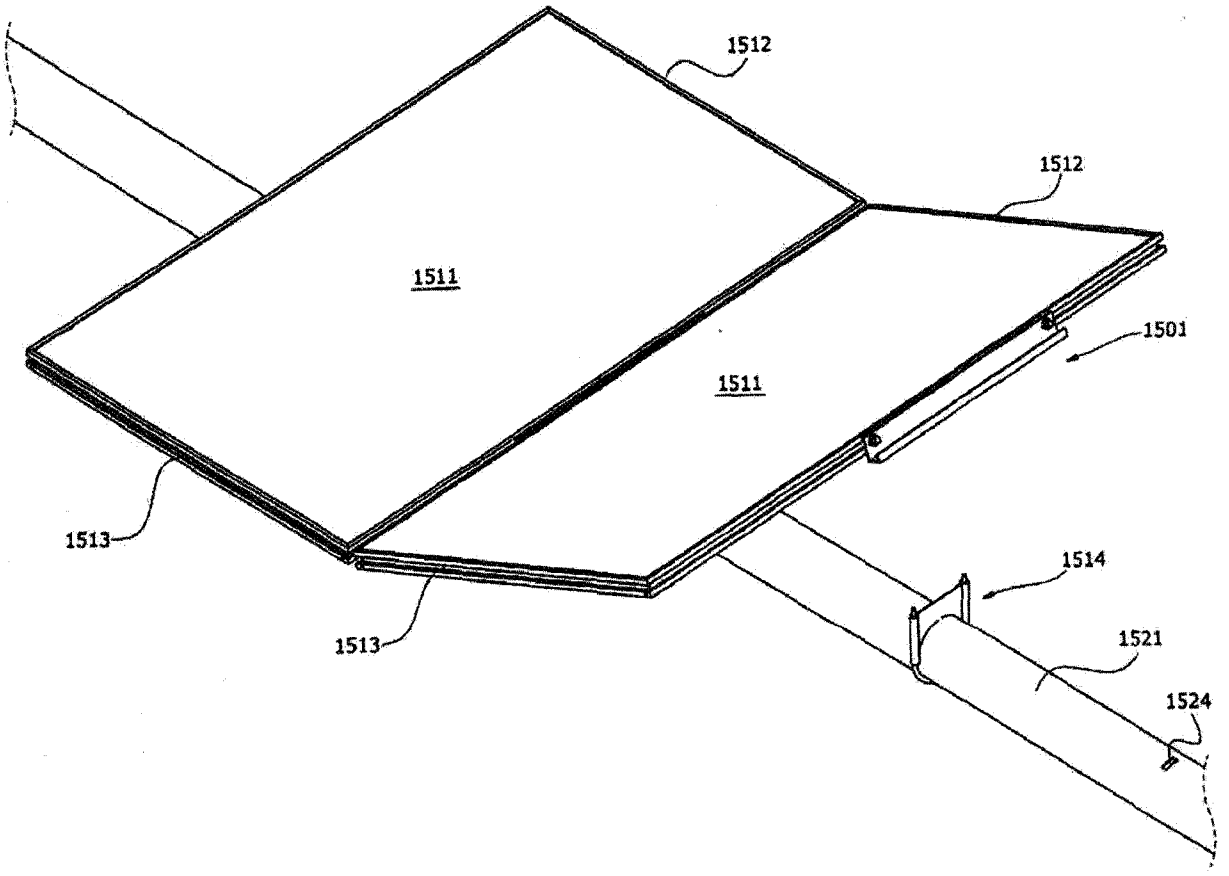


FIG. 15

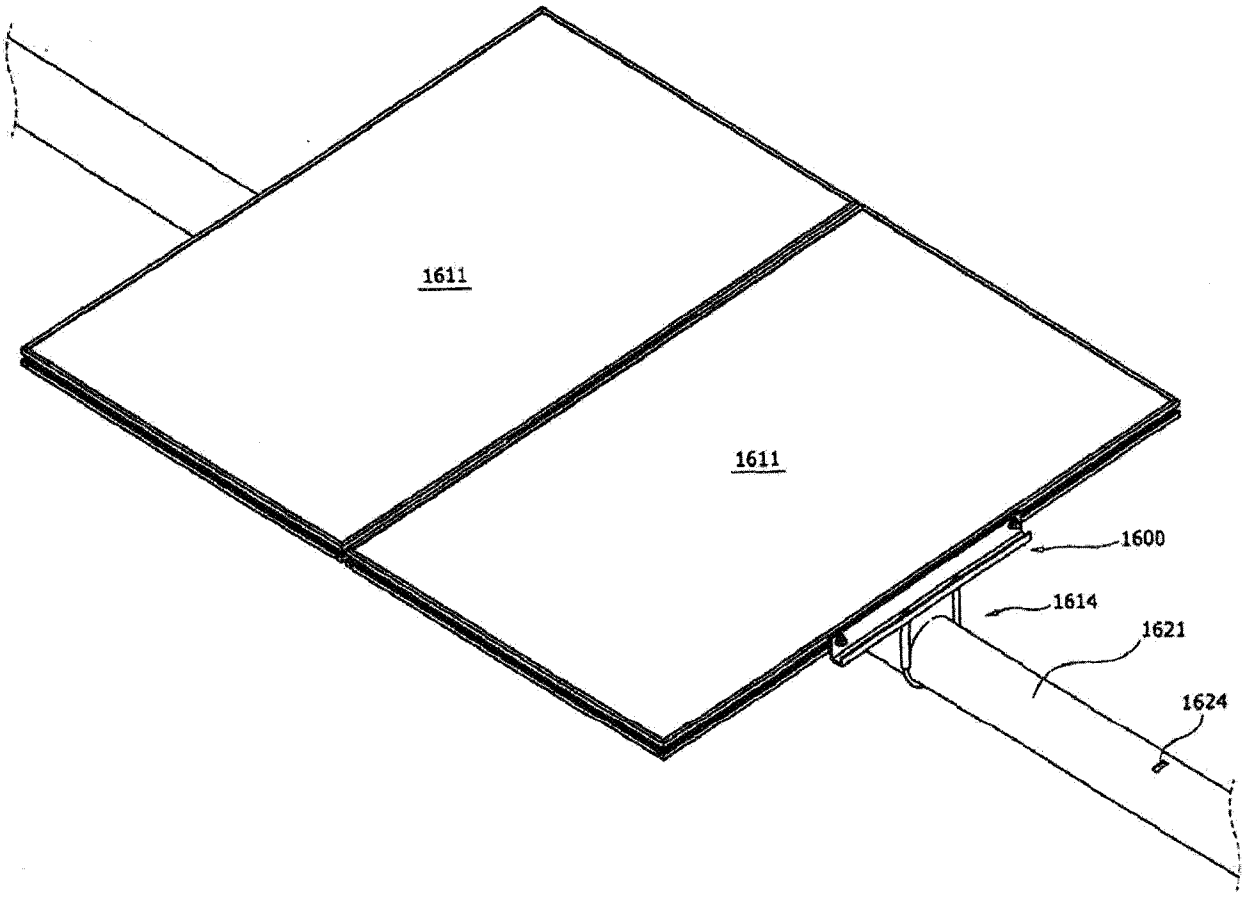


FIG. 16

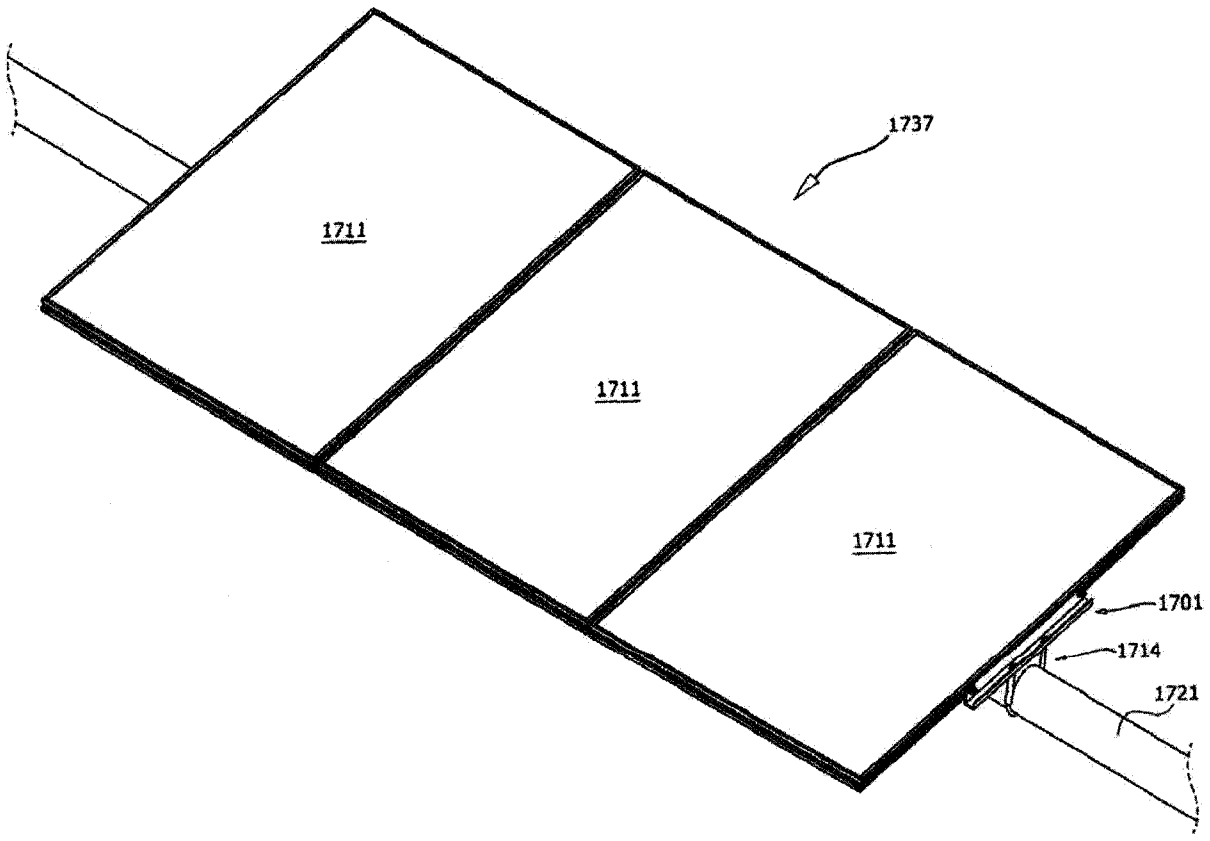


FIG. 17

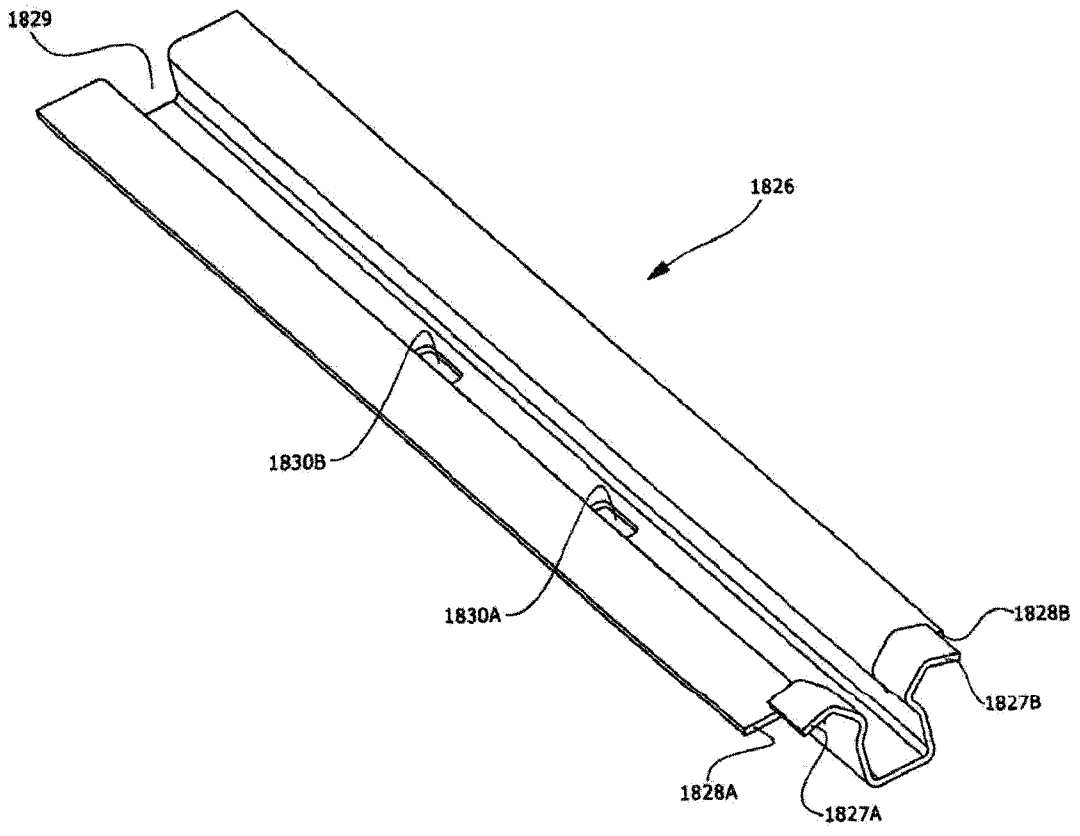


FIG. 18

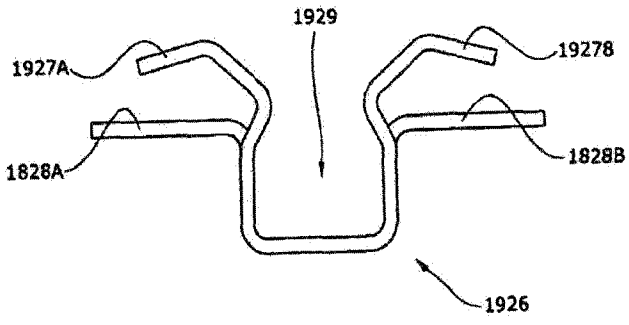


FIG. 19

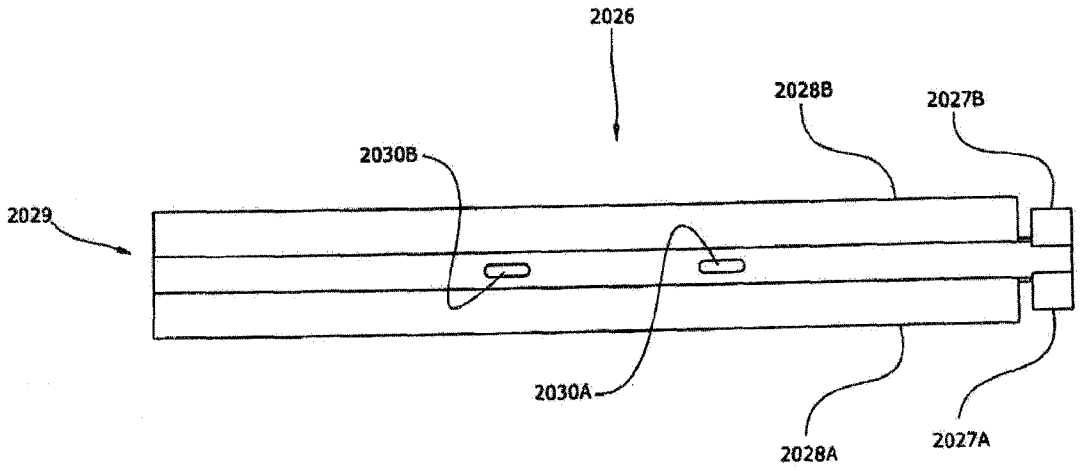


FIG. 20

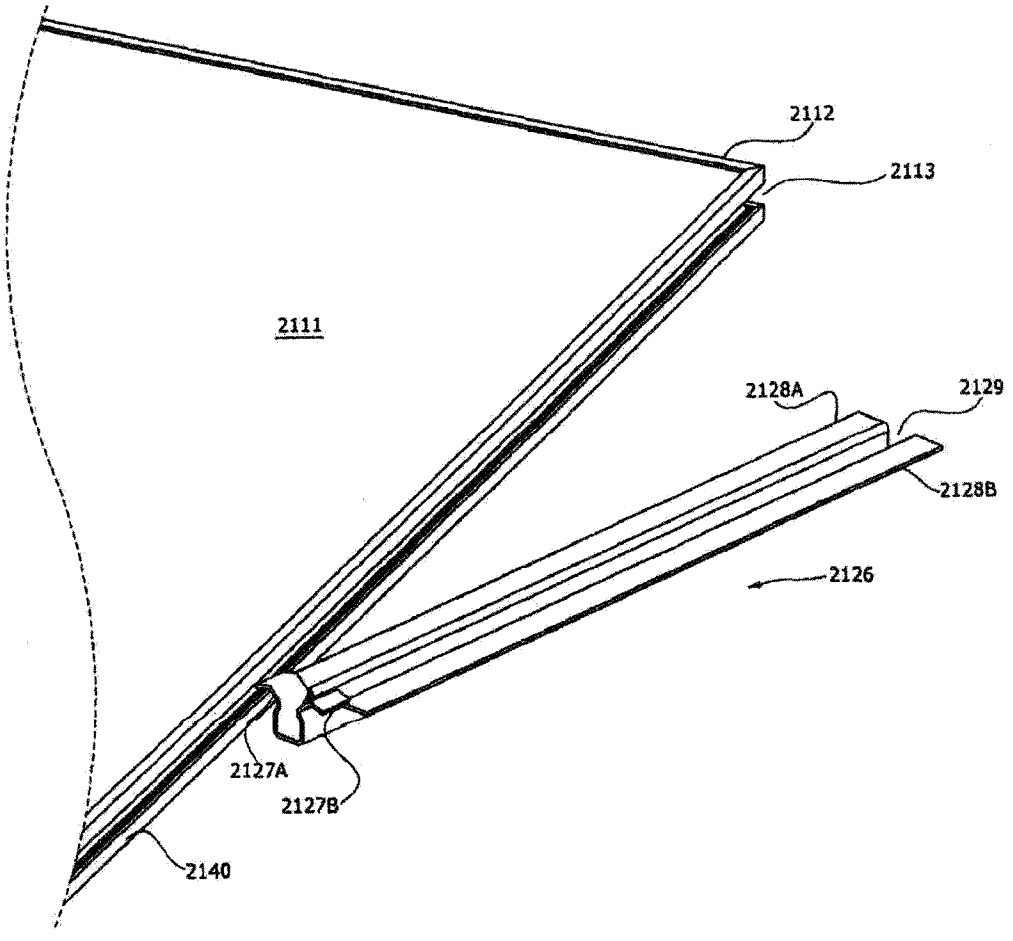


FIG. 21

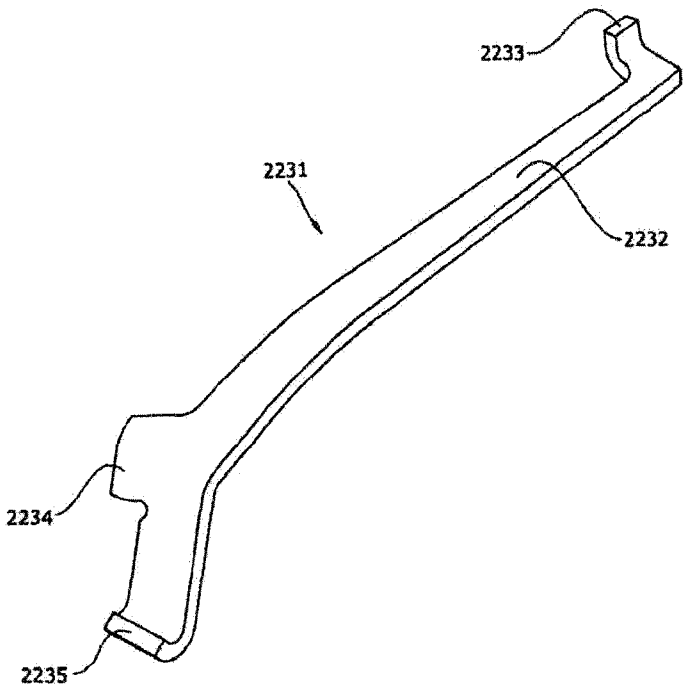


FIG. 22

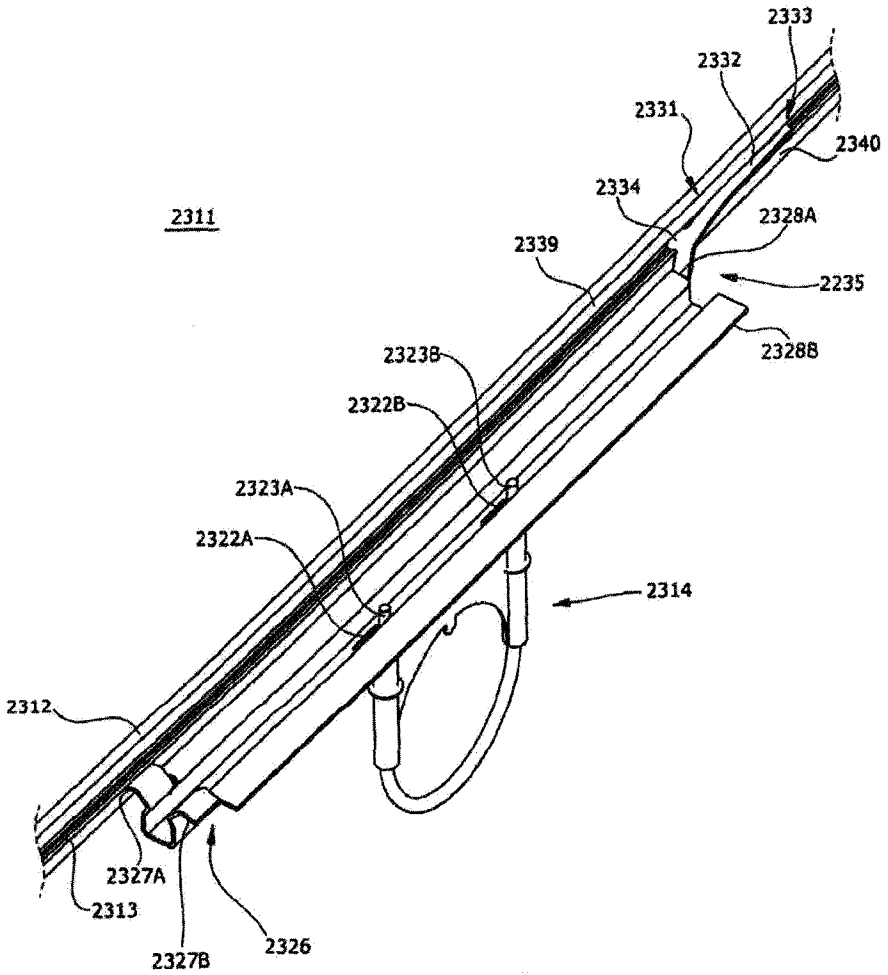

2333
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FIG. 23

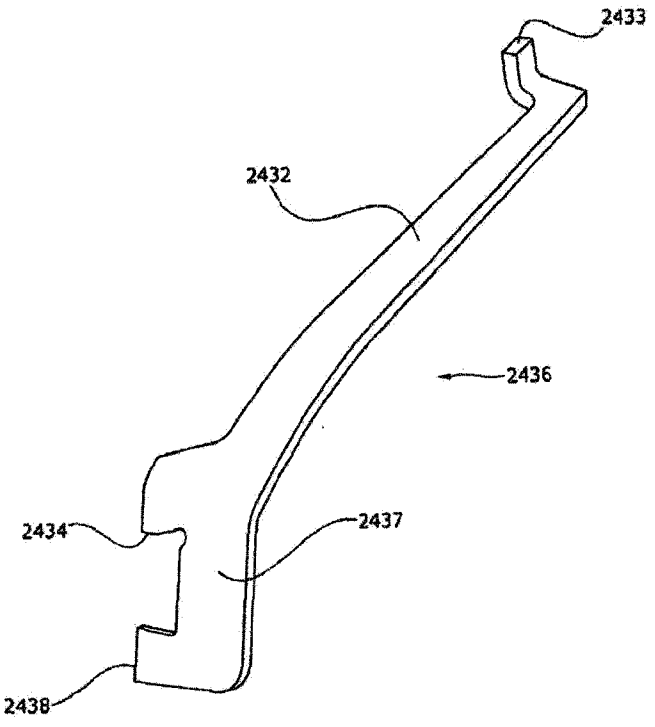


FIG. 24

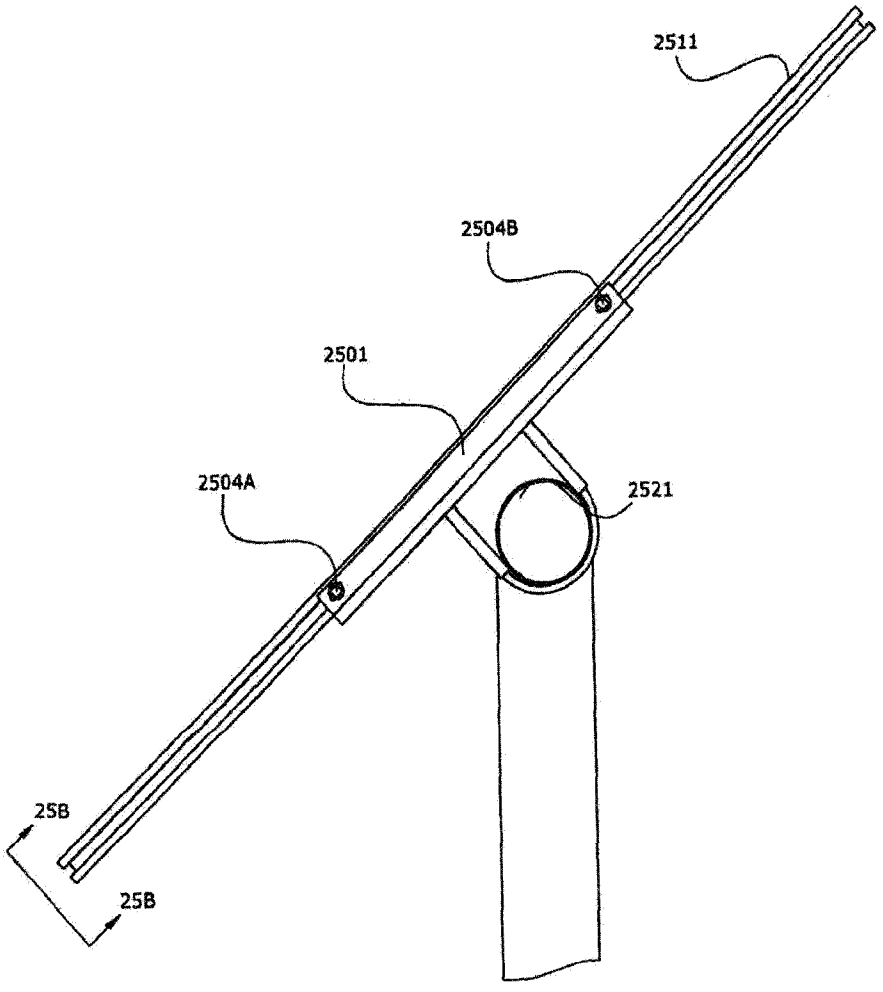


FIG. 25A

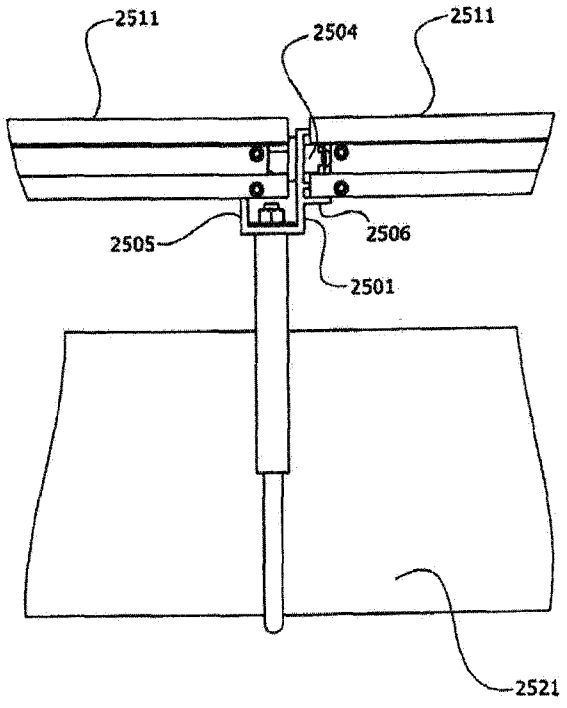


FIG. 25B

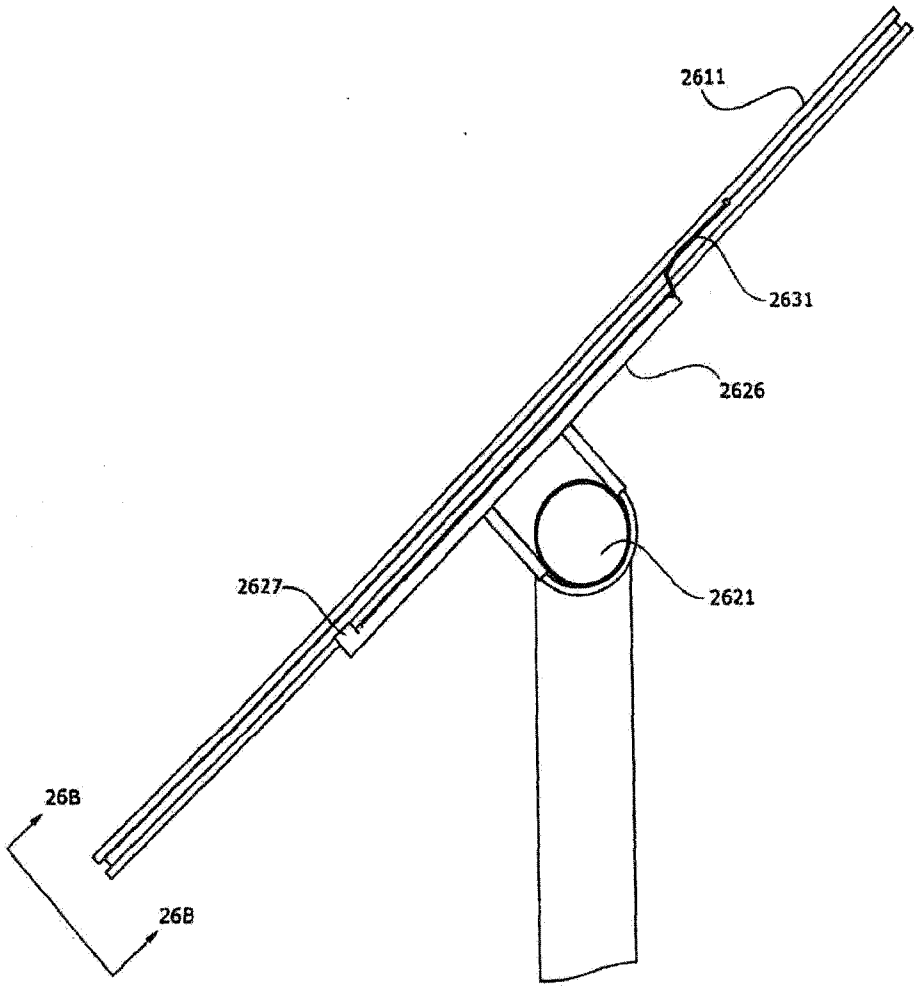


FIG. 26A

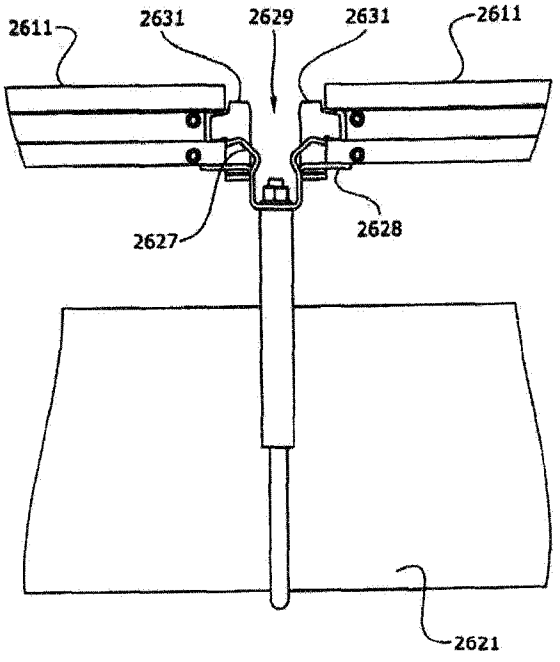


FIG. 26B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 14/18744

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H02S 20/30; F24J 2/54 (2014.01)
USPC - 136/251
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): H02S 20/*, F24J 2/52; F24J 2/54 (2014.01)
USPC: 136/251, 136/244

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
IPC(8): H02S 20/*, F24J 2/52; F24J 2/54; F16B 5/*; F16B 9/*; H01L 31/042 (2014.01)
USPC: 136/244-251; 248/*; 52/*

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents, Google Web
Keywords: rotate, pivot, articulat, swivel, turn, "U ", "U-", interlock, solar, photovoltaic, PV, panel, module, solar, photovoltaic, track, sun, lock, key, lock, U-bolt, mount, rail, frame, mating

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,269,596 B1 (Ohtsuka et al.) 07 August 2001 (07.08.2001), entire document	10-14
X -- Y	EP 2243901 A2 (Widmayr) 27 October 2010 (27.10.2010), entire document	21-22 --- 15-16, 20
Y	US 8,375,654 B1 (West et al.) 19 February 2013 (19.02.2013), entire document	1-7, 9
Y	US 2011/0041834 A1 (Liao) 24 February 2011 (24.02.2011), entire document	1-7, 9, 15-16, 20
A	ES 1066823 Y1 (Casas et al.) 16 June 2008 (16.06.2008), entire document	1-22
A	DE 202006018634 U1 (Schuhmacher) 15 March 2007 (15.03.2007), entire document	1-22
A	WO 2008/046937 A1 (Bofill et al.) 24 April 2008 (24.04.2008), entire document	1-22

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search	Date of mailing of the international search report
23 May 2014 (23.05.2014)	23 JUN 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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